
रॉक मास में दरारों के मात्रात्मक विवरण के
तरीके
भाग 7 भराई
(पहला पुनरीक्षण)

Methods for Quantitative Description
of Discontinuities in Rock Masses
Part 7 Filling
(First Revision)

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FOREWORD

This Indian Standard (Part 7) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

A series of Indian Standard on test methods for assessing the strength characteristics of rocks and rock masses are being developed/revised in view of recent advances in the field of rock mechanics. The majority of rock masses, in particular, those within a few hundred metres from the surface, behave as discontinuous, with the discontinuities largely determining the mechanical behaviour. It is, therefore, essential that structure of a rock mass and the nature of its discontinuities are carefully described and quantified to have a complete and unified descriptions of rock masses and discontinuities. Careful field descriptions will enhance the value of *in-situ* tests that are performed since the interpretation and extrapolation of results will be made more reliable.

Discontinuity is the general term for any mechanical discontinuity in a rock mass, along which the rock mass has zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistosity planes, weakness zones, shear zones and faults. The ten parameters selected for rock mass survey to describe discontinuities are orientation, spacing, persistence, roughness, wall strength, aperture, filling, seepage, number of sets and block size. These parameters are also evaluated from the study of drill cores to obtain information on the discontinuities.

It is essential that both the structures of a rock mass and the nature of its discontinuities are carefully described for determining the mechanical behaviour. This Indian Standard, covering various parameters to describe discontinuities in rock masses.

This standard (Part 7) covers the methods for quantitative description of discontinuities in rock masses for filling. This standard (Part 7) was first formulated in 1987. This revision incorporates the latest advancement and modifications based on the experience gained in the use of this standard. The other parts formulated in the series are:

- | | |
|---------|--|
| Part 1 | Orientation |
| Part 2 | Spacing |
| Part 3 | Persistence |
| Part 4 | Roughness |
| Part 5 | Wall strength |
| Part 6 | Aperture |
| Part 8 | Seepage |
| Part 9 | Number of sets |
| Part 10 | Block size |
| Part 11 | Core recovery and rock quality designation |
| Part 12 | Drill core study |

Filling describe the material that separates the adjacent rock walls of a discontinuity, which is usually weaker than the parent rock. Typical filling materials are sand, silt, clay, breccia, gouge, mylonite. Also include thin mineral coatings and healed discontinuities, for example, quartz veins.

The composition of the Committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

METHODS FOR QUANTITATIVE DESCRIPTION OF DISCONTINUITIES IN ROCK MASSES

PART 7 FILLING

(*First Revision*)**1 SCOPE**

This standard (Part 7) covers the method for the quantitative description of filling in the discontinuities in the rock mass.

2 REFERENCES

The standards listed in Annex A contain provisions which though reference in the text, constitute provision of this standard. At the time of publication, the edition indicated were valid. All standards are subject to revision, and parties to investigate the possibility of applying the most recent edition of these standards.

3 TERMINOLOGY

For the purpose of this standard, the definitions of terms given in IS 11358 shall apply.

4 GENERAL

4.1 Filling is the term for material separating the adjacent rock walls of discontinuities, for example, calcite, chlorite, clay, silt, fault gouge, breccia, etc. The perpendicular distance between the adjacent rock walls is termed the width of the filled discontinuity, as opposed to the aperture of a gapped or open feature.

4.2 Due to the enormous variety of occurrences, filled discontinuities display a wide range of physical behaviour, in particular as regards their shear strength, deformability and permeability. Short-term and long-term behaviour may be quite different such that it is easy to be misled by favourable short-term conditions.

4.3 The wide range of physical behaviour depends on many factors of which the following are probably the most important:

- a) mineralogy of filling material;
- b) grading or particle size;
- c) over-consolidation ratio;
- d) water content and permeability;
- e) previous shear displacement;
- f) wall roughness;
- g) width; and
- h) fracturing or crushing of wall rock.

4.4 Every attempt should be made to record the above factors, using quantitative descriptions, where possible, together with sketches and/or colour

photographs of the most important occurrences. Certain index tests are suggested for a closer investigation of major discontinuities considered to be threat to stability. In special cases, the result of these field descriptions may warrant the recommendation for large scale *in-situ* testing, at least in the case of dam foundations or major slopes.

5 PROCEDURE

5.1 The minimum and maximum widths of simple filled discontinuities (for example, clay filled joints) should be measured to the nearest 10 percent and an estimate made of the most common (modal) width. Marked differences between the minimum and maximum widths may indicate that shear displacement has occurred if the walls are essentially unaltered or unweathered.

5.1.1 In cases where fillings are thin it may be helpful to try to measure the mean amplitude of wall roughness using the straight edge, and compare this with the mean width of the filling as illustrated in Fig. 1. This will be especially valuable when assessing shear strength and deformation characteristics in detailed studies.

5.1.2 The principal dimensions of complex filled discontinuities (for example, shear zones, crushed zones, faults, fault zones, dykes and lithological contacts) should be estimated, or measured to the nearest 10 percent, when possible. In the case of important occurrences, it is helpful to make field sketches such that the condition of the wall rock (that is, degree of associated fracturing and/or alternation) is also communicated (*see* examples in Fig. 2).

5.2 Filled discontinuities that have originated as a result of preferential weathering along discontinuities may have fillings composed of decomposed rock, or disintegrated rock. The relevant type should be recorded:

- a) *Decomposed* — The rock is weathered to the condition of a soil in which the original material fabric is still intact, but some or all of the mineral grains are decomposed; and
- b) *Disintegrated* — The rock is weathered to the condition of a soil, in which the original material fabric is still intact. The rock is friable, but the mineral grains are not decomposed.

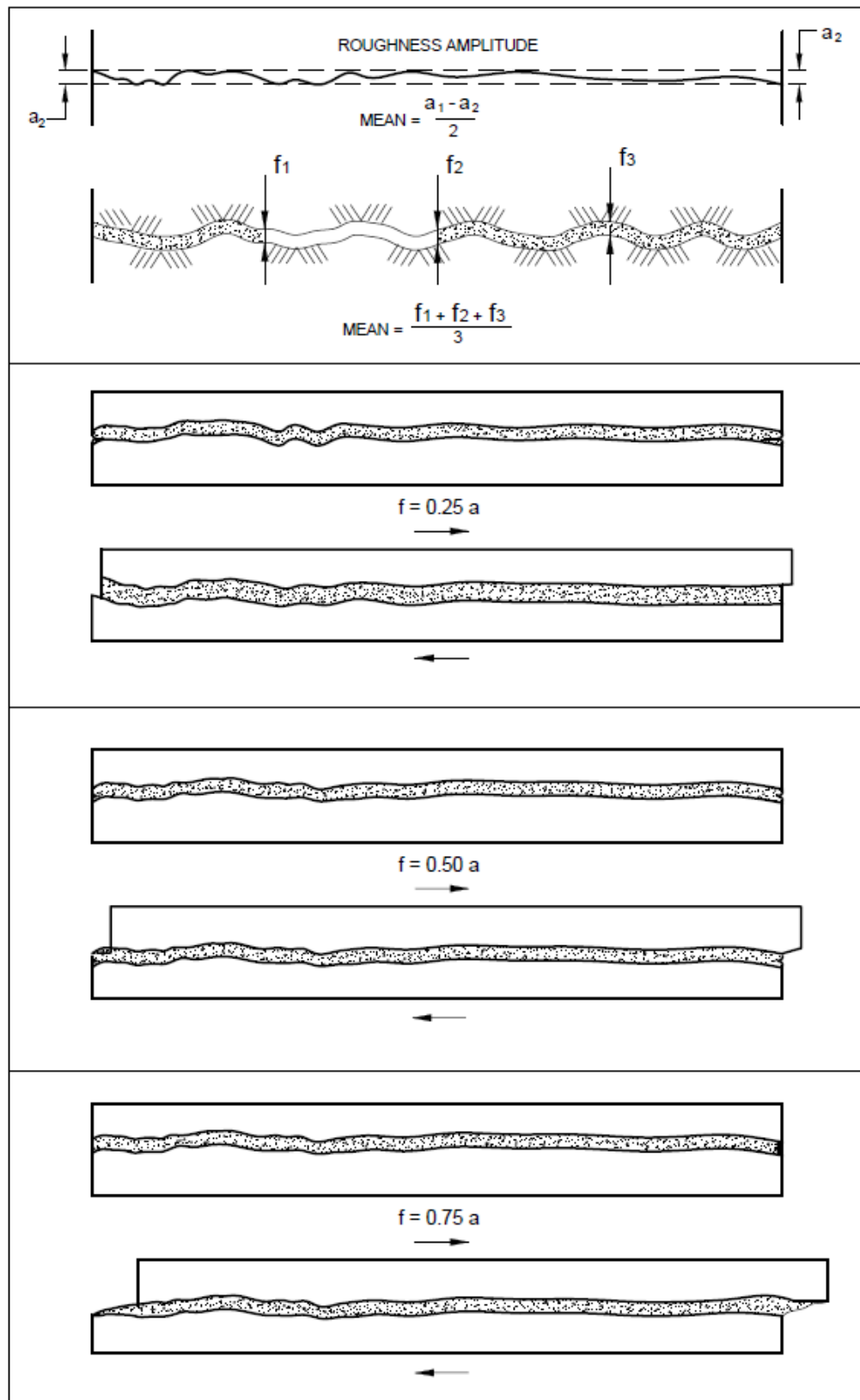


FIG. 1 IN THE CASE OF SIMPLE FILLED DISCONTINUITIES, THE AMPLITUDE OF THE WALL AND THICKNESS OF THE FILLING CAN HELP TO INDICATE THE AMOUNT OF SHEAR DISPLACEMENT REQUIRED FOR ROCK CONTACT (STIFFENING) TO OCCUR (ZERO VOLUME CHANGE ASSUMED DURING SHEAR)

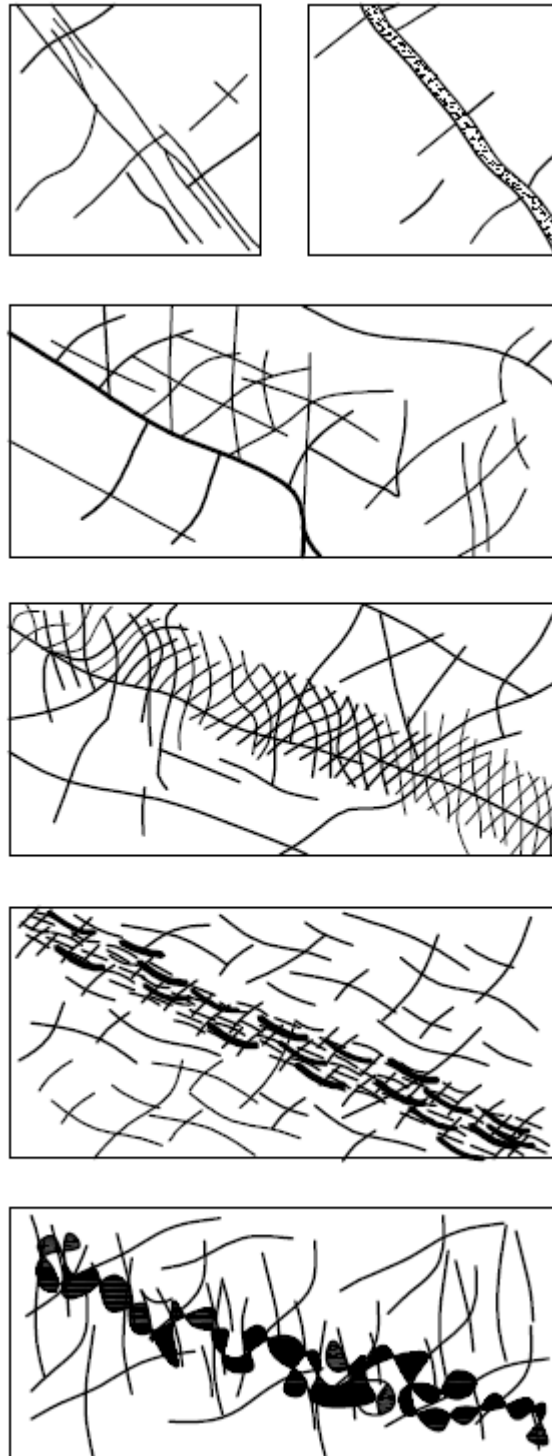


FIG. 2 EXAMPLE OF FIELD SKETCHES OF COMPLEX FILLED DISCONTINUITIES

5.3 For all types of filled discontinuities the finest fraction of the filling or gouge is of most interest since this usually controls the long-term shear strength. The mineralogical composition of the finer filling material should, therefore, be determined, especially in cases where active clays or swelling clays are suspected. Samples should be taken when in doubt concerning the mineralogy.

NOTE — Hydrothermal alteration of gouge material and/or the deposition of hydrothermal products will complicate the mineralogical identification of fillings since products not associated with the petrography of the crushed rock or the wall rock may be present.

5.3.1 In cases where swelling clay such as montmorillonite is identified or suspected, and where this condition might be critical for stability, samples should be taken for free swelling and swelling pressure tests. (It is of advantage of record the *in-situ* water content of these samples, where possible. Such samples should, therefore, be sealed).

5.4 The method of describing the grading or particle size will depend on the type of occurrence. A rough quantitative description of the grading of discontinuity fillings can be given by estimating the percentages of

clay, silt, sand and rock particles (± 10 percent). Several kilos of filling material may need to be extracted and fingered before making these estimates.

5.4.1 Particle size can be classified as under according to IS 1498:

- a) Boulders;
- b) Cobbles;
- c) Coarse gravel;
- d) Medium, gravel;
- e) Fine gravel;
- f) Coarse sand;
- g) Medium sand;
- h) Fine sand; and
- j) Silt, clay.

5.4.2 If a detailed soil mechanics investigation is warranted, the first fraction can be analyzed in the laboratory to determine clay fraction liquid limit and plasticity index, according to relevant method given in relevant part of IS 2720.

5.5 Filling material, in particular the finer fraction which is usually weakest, can be assessed by means of the manual index tests given in Table 1.

Table 1 Manual Index

(Clause 5.5)

| Sl No. | Grade | Description | Field Identification | Approximate Range of Uniaxial Compressive Strength Mpa |
|--------|-------|-----------------|---|--|
| (1) | (2) | (3) | (4) | (5) |
| i) | S1 | Very soft clay | Easily penetrated several inches by fist | < 0.025 |
| ii) | S2 | Soft clay | Easily penetrated several inches by thumb | 0.025 to 0.05 |
| iii) | S3 | Firm clay | Can be penetrated several inches by thumb with moderate effort | 0.05 to 0.10 |
| iv) | S4 | Stiff clay | Readily indented by thumb but penetrated only with great effort | 0.10 to 0.25 |
| v) | S5 | Very stiff clay | Readily indented by thumbnail | 0.25 to 0.50 |
| vi) | S6 | Hard clay | Indented with difficulty by thumbnail | > 0.50 |

NOTE — Grades S1 to S6 apply to cohesive soils, for example clays, silty clays, and combinations of silts and clays with sand, generally allow draining. Discontinuity wall strength will generally be characterized by grades R0-R6 (rock) (*see* Part 6) while S1 to S6 (clay) will generally apply to filled discontinuities.

5.5.1 The undrained shear strengths of the soils represented in grades S1 to S6 are equal to one half of the given uniaxial compressive strengths (care should be taken in applying these estimates to fissured clays).

NOTE — The manual index tests for determining grades S1 to S6 can be replaced by more accurate assessments using a standard soil mechanics penetrometer. This contains a stylus which is pressed into the sample at a constant rate. The maximum resistance can be read off a scale which is calibrated to show the maximum compressive strength of the sample. [This value is equal to twice the undrained shear strength $= \frac{1}{2}(\sigma_1 - \sigma_3)$].

5.5.2 If a detailed soil mechanics investigation is warranted (as in drained shear strength determination) due to critical natures of an individual filled discontinuity, then undisturbed samples of the filling material may be required. Various tube samples are available for this sampling operation.

5.6 Care should be taken to determine whether a given filled discontinuity has suffered previous shear displacement or not (Slickensides, shears, displaced cross joints, etc). This should be recorded in conjunction with an estimate of the approximate over-consolidation ratio (OCR) of any clay filling.

NOTE — If previous displacement has occurred through the potential weakest layers of a filled discontinuity, that is, through the clay filling or clay gouge, as evidenced by slicken sides and shears, then the over-consolidation ratio (OCR) of the clay will not be important since the discontinuity will be close to residual strength. However, if previous displacement through these weak layers is not suspected, then the over-consolidation ratio will be important since the peak drained shear strength of the intact clay may be much higher than the residual strength. Short-term stability will be deceptively high, especially in the case of unloading, due to the reduced or negative pore pressures. However, in time swelling and softening may occur due to increased pore pressure and water content and possibly also due to strain softening caused by engineering loading, for example, by excavation of an overlying rock slope. This potential for reduction in strength with time should not be underestimated during field assessment.

5.7 The water content and permeability of the filled discontinuity as a whole and of the clay filling, in particular, should be described as below. The decision to make actual measurements of these properties will depend on the importance of the occurrence to the project:

W_1 The filling materials are heavily consolidated and dry, significant flow

appears unlikely due to very low permeability.

W_2 The filling materials are damp, but no free water is present.

W_3 The filling materials are wet, occasional drops of water.

W_4 The filling materials show of outwash, continuous flow of water (estimate litres/minute).

W_5 The filling materials are washed out locally, considerable water flow along-out wash channels (estimate litres/minute and describe pressure, that is, low, medium high).

W_6 The filling materials are washed out completely, very high water pressures experienced, especially on first exposure (estimate litres/minute and describe pressure).

NOTE — Faults frequently contain highly permeable brecciated gouge adjacent to highly impermeable clay gouge. The water conducting capacity will therefore be strongly anisotropic, and may even be confined to flow parallel to the plane of the fault. It may be premature to describe a fault zone as dry or impermeable, if the tunnel or exploratory adit has not completely penetrated the feature.

6 PRESENTATION OF RESULTS

The detail of presentation will be dependent on the importance of the individual filled discontinuity (or set) to the project as a whole. In general, the description should be arranged as below, so as to include a description of those factors of particular relevance to project in hand:

- a) *Geometry* — Width wall roughness field sketch;
- b) *Filling type* — Mineralogy particle size weathering grade soil index parameters swelling potential;
- c) *Filling strength* — Manual index (S1 to S6) shear strength over-consolidation ratio displaced/undisplaced; and
- d) *Seepage* — Water content rating as ($W_1 - W_2$) permeability quantitative data.

ANNEX A

(Clause 2)

LIST OF REFERRED STANDARDS

| <i>IS No.</i> | <i>Title</i> | <i>IS No.</i> | <i>Title</i> |
|------------------|---|------------------|--|
| IS 1498 : 1970 | Classification and identification of soils for general engineering purposes (<i>first revision</i>) | (Part 12) : 1981 | Determination of shear strength parameters of soil from consolidated undrained triaxial compression test with measurement of pore water pressure (<i>first revision</i>) |
| IS 2720 | Methods of test for soils: | | |
| (Part 1) : 1983 | Preparation of dry soil samples for various tests (<i>second revision</i>) | (Part 13) : 1986 | Direct shear test (<i>second revision</i>) |
| (Part 2) : 1973 | Determination of water content (<i>second revision</i>) | (Part 14) : 1983 | Determination of density index (relative density) of cohesionless soils (<i>first revision</i>) |
| (Part 3) | Determination of specific gravity, | (Part 15) : 1965 | Determination of consolidation properties (<i>first revision</i>) |
| (Sec 1) : 1980 | Fine grained soils (<i>first revision</i>) | (Part 16) : 1987 | Laboratory determination of CBR (<i>second revision</i>) |
| (Sec 2) : 1980 | Fine, medium and coarse grained soils (<i>first revision</i>) | (Part 17) : 1986 | Laboratory determination of permeability (<i>first revision</i>) |
| (Part 4) : 1985 | Grain size analysis (<i>second revision</i>) | (Part 18) : 1992 | Determination of field moisture equivalent (<i>first revision</i>) |
| (Part 5) : 1985 | Determination of liquid and plastic limit (<i>second revision</i>) | (Part 19) : 1992 | Determination of centrifuge moisture equivalent (<i>first revision</i>) |
| (Part 6) : 1972 | Determination of shrinkage factors (<i>first revision</i>) | (Part 20) : 1992 | Determination of linear shrinkage (<i>first revision</i>) |
| (Part 7) : 1980 | Determination of water content-dry density relation using light compaction (<i>second revision</i>) | (Part 21) : 1977 | Determination of total soluble solids (<i>first revision</i>) |
| (Part 8) : 1983 | Determination of water content-dry density relation using heavy compaction (<i>second revision</i>) | (Part 22) : 1972 | Determination of organic matter (<i>first revision</i>) |
| (Part 9) : 1992 | Determination of dry density-moisture content relation by constant mass of soil method (<i>first revision</i>) | (Part 23) : 1976 | Determination of calcium carbonate (<i>first revision</i>) |
| (Part 10) : 1991 | Determination of unconfined compressive strength (<i>second revision</i>) | (Part 24) : 1976 | Determination of cation exchange capacity (<i>first revision</i>) |
| (Part 11) : 1993 | Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure (<i>first revision</i>) | (Part 25) : 1982 | Determination silica sesquioxide ratio (<i>first revision</i>) |
| | | (Part 26) : 1987 | Determination of pH value (<i>second revision</i>) |
| | | (Part 27) : 1977 | Determination of total soluble sulphates (<i>first revision</i>) |

| <i>IS No.</i> | <i>Title</i> | <i>IS No.</i> | <i>Title</i> |
|------------------|---|------------------|--|
| (Part 28) : 1974 | Determination of dry density of soils, in-place, by the sand replacement method (<i>first revision</i>) | (Part 36) : 1987 | Laboratory determination of permeability of granular soils (constant head) (<i>first revision</i>) |
| (Part 29) : 1975 | Determination of dry density of soils in-place by the core — Cutter method (<i>first revision</i>) | (Part 37) : 1976 | Determination of sand equivalent values of soils and fine aggregates |
| (Part 30) : 1980 | Laboratory vane shear test (<i>first revision</i>) | (Part 38) : 1976 | Compaction control test (Hilf method) |
| (Part 31) : 1990 | Field determination of california bearing ratio (<i>first revision</i>) | (Part 39) | Direct shear test for soils containing gravel, |
| (Part 33) : 1971 | Determination of the density in-place by the ring and water replacement method | (Sec 1) : 1977 | Laboratory test |
| (Part 34) : 1972 | Determination of density of soil in-place by rubber-balloon method | (Sec 2) : 1979 | <i>In-situ</i> shear test |
| (Part 35) : 1974 | Measurement of negative pore water pressure | (Part 40) : 1977 | Determination of free swell index of soils |
| | | (Part 41) : 1977 | Measurement of swelling pressure of soils |
| | | IS 11358 : 1987 | Glossary of terms and symbols relating to rock mechanics |

ANNEX B*(Foreword)***COMMITTEE COMPOSITION**

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